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Innovation and Connectivity: The Nature of Market Linkages and Innovation Networks in Canadian Manufacturing Industries

by John R. Baldwin and Alice Peters

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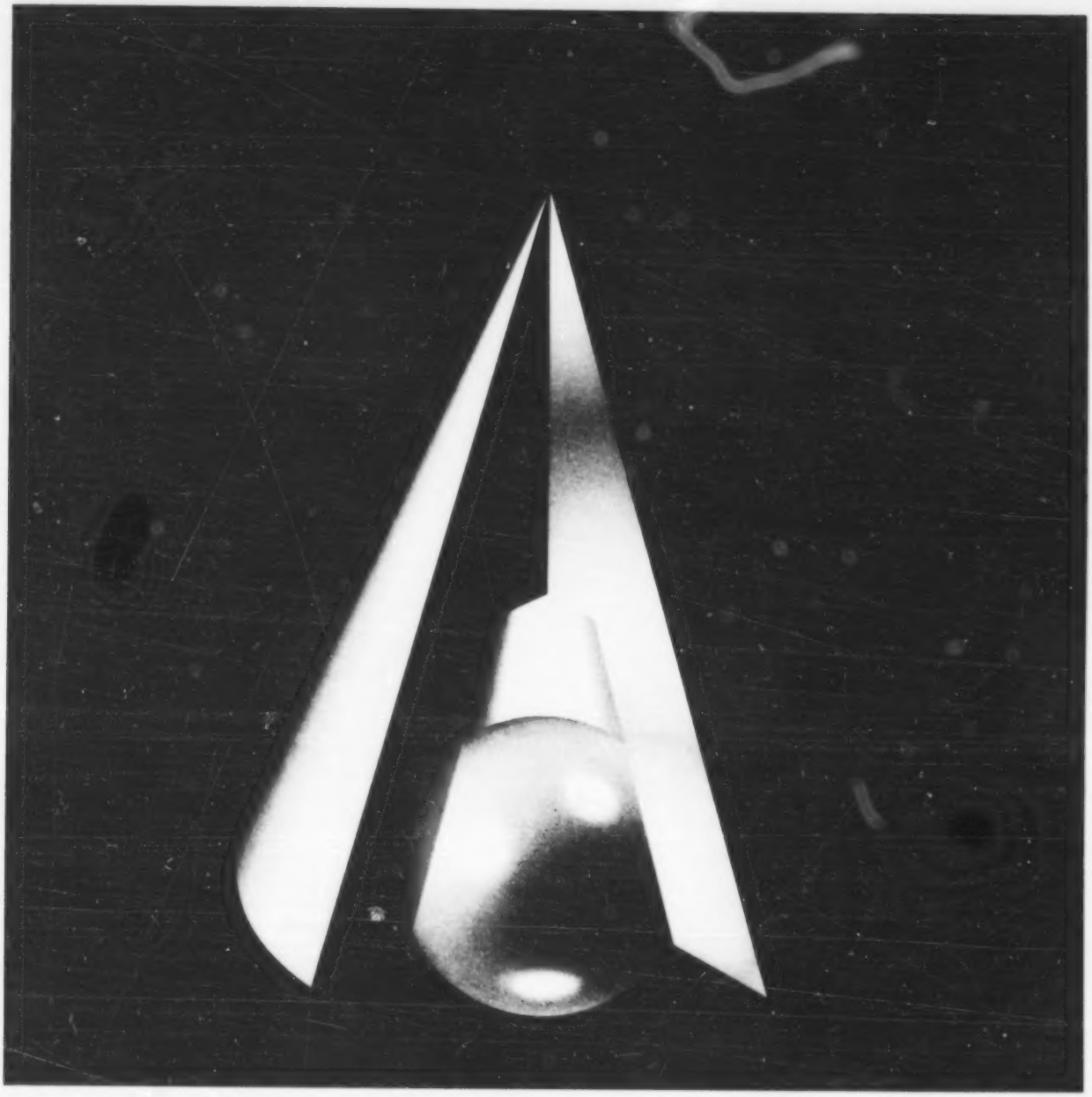

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Table of Contents

ABSTRACT V

ACKNOWLEDGEMENTS VII

1. INTRODUCTION 1

2. THE IMPORTANCE OF CUSTOMER-SUPPLIER INNOVATION NETWORKS 2

3. INTER-INDUSTRY LINKAGES 5

3.1 Number and Magnitude of Backward Linkages with Suppliers 9
3.2 Number and Magnitude of Forward Linkages with Customers 11

4. COMPARISON OF INNOVATION NETWORKS TO INTER-INDUSTRY LINKS 13

5. CONCLUSION 15

APPENDIX A: BACKWARD LINKAGES BY INDUSTRY, 1993 INPUT-OUTPUT DATA 16

APPENDIX B: FORWARD LINKAGES BY INDUSTRY, 1993 INPUT-OUTPUT DATA 20

APPENDIX C 24

REFERENCES 28

Abstract

This paper investigates the extent to which customers/suppliers innovation networks are related to the size and pattern of inter-industry goods flows. It does so by devising a diversification index to measure the nature of inter-industry links that arise from the flow of goods and services from suppliers to customers. It then relates these diversification patterns to the importance of customer and supplier innovation networks.

Input/output matrices are used to measure the extent of inter-industry links and the pattern of inter-industry goods flows. The importance of customer/supplier networks is derived from data coming from the 1993 *Survey of Innovation and Advanced Technology*.

The study finds that the importance of supplier and of customer innovation networks is related to the structure of inter-industry trade flows. Where there are a small number of important backward inter-industry links, firms are more likely to make greater use of supplier partnerships. On the other hand, the importance of customer links increases when there is a large number of industry linkages downstream.

Keywords: innovation, connectivity, innovation networks

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1. Introduction

This paper examines the impact of industry interdependence or connectedness on the one feature of the innovation regime. It investigates the relationship between an aspect of the innovation network that supports innovative activity and the extent of industry interdependence. The specific facet of the innovation network that is examined herein involves its reliance on supplier and customer networks. Industry interdependence is measured as the flow of goods and services between industries. This paper uses survey data to measure the importance of cross-industry innovation networks and input-output data to measure inter-industry market linkages.

Customer/supplier links are the focus of this paper because interactions between users and producers of intermediate goods are considered one of the ingredients required for successful innovation regimes. Innovation is seen as a process that often evolves most successfully in a network where there is intensive interaction between the buyers and sellers of goods, services, knowledge, and technology.

This occurs because innovation depends on sources of ideas that are both internal and external to the firm. While internal sources such as R&D departments are important to the innovation process, so too are external sources—sources such as customers and suppliers. Customer and supplier sources of ideas for innovation are associated with the evolution of networks—networks through which ideas are exchanged, or more importantly, the fruits of research (coming from R&D or production departments) are transferred either forward to customers or backward to suppliers. This transfer process is one route through which the classic problem of externalities associated with knowledge information is internalized—because supplier/customer linkages involve transactions that transfer ideas as part of a joint package that combines the flow of intermediate goods and embodied knowledge—thereby creating the appropriate incentive mechanisms required for investment in the knowledge that is essential to innovation.

Both the importance and the pattern of these supplier/customer linkages are, therefore, of interest. Previous work has shown that customer and supplier linkages are more important in smaller firms (Baldwin, 1997). They are also more important in industries where R&D is less important (Baldwin and Hanel, 2002). Therefore, industry environment is related to the type of innovation network that emerges in different innovation systems. The aspects of the environment that have interested us in the past relate to the complexity of the innovation process—whether the sector or firm is extremely innovative (Baldwin and Da Pont, 1996).

This paper examines whether the nature of inter-industry goods and service flows also affects the tendency of customer and suppliers to rely upon one another as part of an innovation network. In some industries, self-sufficiency is high. There are few sales to or purchases from any other industry. In other industries, there are one or two very significant links to other industries. In still other industries, there are links to many other industries. It is our intent here to examine whether the importance of supplier/customer innovation networks varies in a systematic way across industries that is related to the type and importance of these inter-industry links.

In order to do so, the paper proceeds first by outlining the importance of customer/supplier networks to the innovation process. It then identifies the types of trade linkages between industries, i.e., identifying industries that are related through the purchase of intermediate goods from, or sale of intermediate goods to, each other through the use of the Canadian input/output tables. Next, it provides measures of the number and magnitude of inter-industry linkages and the concentration or diversity of those linkages. Finally, the inter-industry linkage information is complemented with data from the *1993 Innovation and Advanced Technology Survey* on the importance of customers and suppliers as sources of ideas for innovation. In the final section, the paper assesses whether an industry's reliance on customer/supplier networks is related to its tendency to be closely linked to other industries.

2. The Importance of Customer-Supplier Innovation Networks

The innovation process relies heavily on knowledge or ideas from both inside and outside the firm. While much emphasis has been placed on the importance of internal sources such as the R&D group, external sources also play an important role. Ideas for innovations originate often outside the firm in response to market opportunities, new information and competition and/or collaboration with other firms and institutions.

These outside sources are diverse. Some come from market partners—either from firms that are associated with arm's-length transactions (customers or suppliers) or firms that are part of the same ownership group (related firms). In each of these cases, the transfer of information that supports innovation is accompanied by some other transaction and, therefore, potentially allows for the pricing of the information flow. In the case of consumers and suppliers, the information can be included in the price that is paid for a good or service. In the case of related firms, the contractual relation that is relevant involves ownership and the consideration that accompanies a transfer of information may be a direct payment for information or can be part of the profits remitted to the parent firm. In both cases, the existence of this consideration is a method of dealing with imperfections in knowledge markets.

Some ideas for innovation come via other market transactions with third parties—consultants or private research institutes. Once again, these firms operate as part of a market-driven system where knowledge is transferred as part of a commercial transaction.

A third source consists of what are closer to unpriced spillovers. Here there is less of a well-developed market for the transfer of ideas. These spillovers come closer to the definition of classical externalities, though, in many cases, mechanisms have been developed to provide for some internalization incentives. These sources include public R&D institutions, universities, professional trade literature, trade fairs and exhibitions, and patent offices. In this document, this group will be referred to as the technological infrastructure. Competitors also fall in the group that provide unpriced spillovers. Although some of the knowledge that is derived from competitors may come from joint projects and may be more akin to a market relationship that involves an exchange of resources, much of this type of spillover occurs from the observance of competitors' behaviour and the reverse engineering of competitors' products.

Information on the importance of these different sources is available from the Canadian *1993 Innovation and Advanced Technology Survey* that covered manufacturing establishments and firms of all sizes. This survey was based on a frame of all Canadian firms in manufacturing that was taken from Statistics Canada's Business Register. The sample was randomly drawn from a manufacturing population that was stratified by size, industry, and province.

The survey explored the nature of the innovative process by examining the innovative characteristics of firms and their plants. Firms were asked, in particular, about the role of customers and suppliers as sources for ideas and information for innovation, and about their collaboration partners, including customers and suppliers.

The importance of each of these external sources is measured here as the percentage of firms that make use of one of the sources (Table 1).[1]

It is clear that the innovation process depends very heavily on the diffusion of information from firm to firm. Some 85% of innovators used at least one of the external sources. The most frequently cited external source of new ideas comes from market-related partners (customers, suppliers, and related firms), which is used by 68% of all innovators (Table 1).

Clients are important for 46% of firms. Innovation is, in these cases, demand driven. Many innovations are inspired by suggestions of clients and originate in firms that pay careful attention to the needs of their customers.

Many have also stressed that innovation is determined by the technological opportunities available—by the supply of new ideas (Cohen and Levin, 1989). The importance of technological opportunities is confirmed by the fact that the external source with the second highest importance is suppliers, with 28% of firms using this source.

Other market transactions (consultants and private R&D institutions) are less important, being cited by only 15% of innovators. Consultants are important for only about 13% of firms. The difference between the importance of market-related partners (68%) and market transactions with consultants and private R&D institutes (15%) emphasizes the relative importance of diffusion that occurs within well-defined networks that are connected by either goods flows or ownership. Based on this evidence, there are substantial difficulties in organizing transactions for research activities outside these normal commercial relationships.

Spillovers from the technological infrastructure and competitors also play an important role in the innovation process. Some 46% of firms report that they obtain information from one of these sources. Competitors are the most important group within this category, with 28% reporting that they derived information from this source. This is almost as important as are suppliers in the group of market-related partners. This indicates the importance of the diffusion of ideas from sources that involve externalities. Other externalities come from sources that are termed the "technological infrastructure". Trade fairs are second in this group at 17%. Next are professional publications at 13%. Universities, public R&D institutions and the patent system are each listed as important sources by less than 3% of innovative firms.

[1] These data are taken from the 1993 *Survey of Innovation and Advanced Technology*.

While supplier/customer networks play a critically important role in the innovation process, their use varies across sectors and across firm types. Supplier linkages tend to be more important in those industries that consume innovations that are produced elsewhere. Both supplier and customer linkages are used more by small firms than large firms. They are used less in firms that are producing the most novel innovations and more in those who are introducing innovations that modify and improve existing products (Baldwin and Hanel, 2002).

Table 1. Principal External Sources of Ideas for Innovations

External Source of Ideas	*% of Innovating Firms*
Market-Related	68
Suppliers	28
Clients-Customers	46
Related-Firms	15
Market-Transactions	15
Consultants	13
Private R&D Institutions	4
Spillovers	46
Competitors	28
Trade Fairs	17
Professional Publications	13
Public R&D Institutions	3
Patent Office	3
Universities and Colleges	3

In a related study (Baldwin and Hanel, 2002), the patterns that have been observed in the use of customer/suppliers linkages within the innovation network have been related primarily to characteristics that related to complexity of the innovation process. This study examines whether the importance of customer/supplier innovation networks by industry varies with the type of inter-industry trade flows that link industries to one another.

The strength of supplier and customer trading linkages may have quite different affects on the type of innovation network that is put in place. Supplier networks are often used to adopt materials. But this process is expensive and complex. When links are strong between two industries, the high costs of coordinating the innovation network to accomplish this may be offset by the benefits associated with the size of the trade-flows between the two industries. In turn, this suggests that there will be a correlation between the importance of a supplier network and the concentration of trade flows into a small number of important inter-industry linkages.

On the other hand, customer innovation networks may involve a considerably different benefit—one where each customer provides a potential idea, each of which is equally valued in its own right, and where the value of the idea pertains to all sales, not just to the sales made to that particular customer. In this case, greater diversification across industries with regards to downstream flows should be associated with a larger set of ideas flowing back to the firm that stimulate product innovation. Customer innovation networks between industries are then more

likely to develop when downstream inter-industry trade flows between industries are more diversified.

To examine these issues, the input/output matrices are used to describe trade flows between industries. These matrices are used to develop summary statistics that describe the extent to which an industry is linked to others and then the relationship between the importance of these flows and the importance of supplier/customer innovation networks is examined. The next section outlines the methodology that is used to develop summary statistics that describe the extent to which industries are linked together by goods and services flows.

3. Inter-industry Linkages

The concept of inter-industry "linkages" has long been prominent in economic history (Innis, 1933) and in the economic development literature. The economic history literature has focused generally on the evolutionary patterns associated with economic development, studying how linkages change as economies evolve. Sometimes, new linkages result from the creation of new downstream industries to replace foreign supply sources (for example, a domestic steel industry developing to meet widespread demand for steel). Sometimes, it involves the creation of new upstream industries to upgrade the value chain, i.e., to replace low value exports (for example, a flour milling industry that evolves as an adjunct of an agricultural economy that relied at first on just wheat exports). Albert Hirschman has advanced similar concepts in the development literature by explaining how inter-industry linkages evolve and are important to economic development policy (Hirschman, 1958). The Hirschmanian model suggests that *backward linkage effects* will sometimes induce downstream industries to attempt to supply the inputs on which they have previously relied, and *forward linkage effects* will induce industries to attempt to extend their production into industries that they have previously supplied on an arms-length basis.

Because of the desire to study how complementary strengths across linked industries can reinforce the overall success of groups of industries, many have used cluster analysis to identify related groups of industries with inter-industry links. Cluster analysis is built on the hypothesis that linkages across different activities are integral to the performance of the groups as a whole. This type of analysis has been undertaken at several levels:

- Case studies, which are generally based on Porter's diamond, provide detailed information about actors, behaviours and strategies within the cluster network (Porter, 1986).
- Micro-level cluster analysis is also used to identify small-scale clusters and firm linkages, usually on a geographic basis (Bergman et al., 1997; Czamanski, 1974; Bergman and Feser, 1997).
- Industry-based cluster analysis is also commonly done using input-output tables (Richardson, 1972).

Since the aspect of an innovation network that is examined here (customers and suppliers) is related to the interdependence across industries that is associated with goods flows, input-output data is used to define inter-industry dependencies. The universe of linkages is divided into forward linkages (downstream) and backward linkages (upstream) to correspond to these two sources of ideas—customers and suppliers.

Forward linkages identify the users of an industry's products. The importance of a forward linkage from industry A to industry B is measured by the proportion of the total use of the output of an industry A that is purchased by industry B.

Backward linkages identify the main suppliers of an industry. The proportion of the total purchased intermediate inputs of industry A that come from industry C measures the importance of a backward linkage from A to C.

The 1993 Canadian input-output tables at the L level of aggregation (167 industries) is used to ascertain the nature and importance of inter-industry trade linkages. These tables provide measures of the origin of each industry's purchases as well as the destination of each industry's sales. For the former, the "*use*" matrix is employed. The columns of the *use* matrix describe how much of each commodity is used by each industry. For the latter, the "*make*" matrix is employed. The rows of the *make* matrix describe how much of each commodity is made by a particular industry.

Together, the *use* and *make* matrices are employed to determine the percentage of an industry's purchases from, or sales to, other industries. These data will be used to summarize the pattern and importance of inter-industry good flows.

The calculation of the inter-industry purchases or sales is discussed separately for backward linkages and forward linkages. In this exercise, summary statistics are developed for two types of links—intra-industry links (purchases and sales among firms in the same industry), and inter-industry links (purchases and sales among firms not in the same industry). The linkages are divided into these two groups because it is possible that the incentive to create innovation networks may be quite different for firms that are connected within the same industry as opposed to firms that are connected by goods flows across industries.

Inter-industry and intra-industry supplier trading linkages are not expected to have the same effects on the innovation network. Firms from outside the industry who supply intermediate products are more likely to be arm's-length firms. Firms within the same industry who are suppliers are firms that are at a lower stage on the value-added chain and provide inputs to firms further along the vertical chain in the same industry. Suppliers in the latter group are more likely to be related firms. It is hypothesized that inter-industry trade flows are more likely to be positively related to the development of arm's-length supplier innovation networks. Industries with large intra-industry linkages would be less likely to develop supplier innovation networks—rather they are more likely to develop related-firm or internal networks (see Table 1). The same holds true of customer networks for innovation ideas.

Input-output matrices provide a picture of the size of the linkages for each industry. But by themselves, they do not provide statistics that are sufficiently simple for our purposes. Summary statistics are needed to describe whether an industry is closely or loosely linked to other industries that can then be statistically related to the measures of the importance of customer/supplier innovation links. Therefore, the information contained in the input/output tables is combined here into a set of summary statistics that characterize an industry as being more or less closely linked to other industries. More than one summary statistic is used because there is more than one dimension to the type of linkage that may determine whether customer/supplier innovation networks are important.

In order to decide on the method to be used to create the required summary statistics, several important issues need to be addressed. They are:

1. How should the degree of an industry's "connectedness" with other industries be defined? By the number of linkages it has? By the magnitude of those links?
2. Is an industry with some large links and few smaller links more "connected" than one with many small links?
3. Should just direct links between industries be measured or should the importance of indirect linkages also be investigated?

The answer to these questions should be derived from a theory of the forces that lead to innovation partnerships.

Supply innovation linkages are seen to involve substantial interfirm co-ordination, in that they involve finding new ways to use materials. Examples include the incorporation of nickel into steel production, or aluminum into automobile production. This process is costly in that it involves developing new processes to make use of materials in new ways and thus requires the reengineering of a firm's production processes. Firms face impediments to devise these types of innovation partnerships with supplier firms, impediments whose severity will be a function of the costs of developing a partnership. These costs involve negotiating the terms and conditions that govern a relationship and are posited in the main to consist of fixed costs—that is, a cost component that is not related to the size of the goods flows between two industries. On the other hand, the benefits of an innovation partnership are hypothesized to be positively related to the size of the linkages—the flow of goods between two industries. Together these two assumptions (that benefits are proportional to the strength of a supplier linkage but a substantial proportion of the costs per supplier linkage are fixed) imply that the probability of a backward supplier partnership being formed is inversely related to the size of the linkage—the larger the flows, the more likely the benefits will be greater than the fixed costs of negotiating the agreement. This implies that there will be fewer supplier partnerships in an industry where that industry has a large number of relatively unimportant backward supply linkages. In contrast, there is a higher probability of forming supplier linkages in an industry when that industry has a large share of its inputs and outputs linked backwards to only one or two other industries.

Alternately, customer innovation networks are also posited to be affected by both the number and importance of downstream linkages, but in a slightly different way. Customers supply ideas as to improvements in the product of a firm that have spillover effects to other customers of a

firm. If the probability of having any customer come up with an innovative idea is about the same across all customers, then the probability of obtaining a good new idea will be a function of how diverse the customer network is. But even here, size of flows is important since the size of the flow is likely to be related to the benefits derived from pursuing customer suggestions.

Therefore, measures are derived for each industry that take into account both the number of linkages to other industries and their size. To do so, only direct linkages between industries are measured. That is, measures are derived only of the size of linkages from industry A to industry B and not those from A to C that run through B. This is because the innovation survey only captures the importance of the direct supplier or customer innovation network.

The first measure used is the percentage of purchases or sales that is made with other firms in the same industry—what are described here as same-industry or intra-industry linkages. Since intra-industry linkages involve closely related firms, these firms might be expected to collaborate through direct partnerships and joint/ventures rather than through customer/supplier links. Thus the importance of innovation networks should be lower where intra-industry sales are more important, unless there are other offsetting effects. One such effect could be the value of the partnership. For example, if customer networks with actual or potential competitors in the same industry had a particularly high value, then intra-industry sales might be positively related to the use that is made of innovation networks.

The second set of measures involves a count of the number of linkages in different categories, where categories are differentiated by order of importance. Inter-industry linkages are classified as very important, of intermediate importance, or of low importance. A link where an industry buys more than 20% of its inputs from another industry is defined as a very important backward link. Analogously, a link where an industry sells more than 20% of its outputs to another industry is considered a very important forward link. Linkages ranging from 10% to 20% are considered of medium importance. Linkages between 1% and 10% and between 0% and 1% are considered as less important. The measure then is the number of upstream (customer) and downstream (supplier) linkages that fall into these categories for each of the 167 industries used in this study.

Finally, a summary statistic is calculated that combines information on the both the number and importance of forward and backward linkages. For this purpose, an entropy measure of the diversity of an industry's linkages is used. For more discussion of the use of this index, see Baldwin, Beckstead and Gellatly, 2000. It is defined as:

$$E_i = \sum_{i=1}^{N} s_i \log (1/s_i)$$

where E_i = entropy of industry i,
N = number of industries, and
s_i = share of purchases or sales of industry i

This measure captures how concentrated, or conversely, how diverse an industry's purchases from or sales to other industries are. The entropy measure takes a value of zero when inter-industry trade flows are concentrated within a single industry pair. At the other extreme, if the industry's trade is spread evenly across K industries, the entropy is maximized at E(s) = log (K).

In this paper, the entropy measure of diversification is transformed by taking its antilog. This takes a value of one when 100% of purchases or sales are made to just one other industry. It takes a value of N when an industry's purchases or sales are spread equally to all N industries. Other situations that fall in between are characterized by a numbers-equivalent, which represents the number of industries over which an industry's purchases or sales would need to be equally spread to have the same value as the diversity measure.

Consider, for example, an industry that sells to 15 industries and 5 of these industries each account for 15% of the industry's sales, another 5 each account for 4% of the industry's sales, and the remaining 5 each account for 1% of the industry's sales. This industry is not as diversified as one with sales evenly divided among 15 industries. It is more diversified, however, than one with sales evenly spread across 5 industries, because its sales are spread evenly across 5 industries and it also sells to 10 more industries. The weighting scheme embodied in the entropy formula places this industry between the two more extreme cases. According to the entropy formula, the value of E for this industry is 7.3, which means that the industry is about as diversified as one with sales evenly spread across 7 industries.

3.1 Number and Magnitude of Backward Linkages with Suppliers

Both inter- and intra-industry links are considered here. Linkages involving firms in one industry with suppliers in other industries are characterized as inter-industry linkages. Linkages between firms in the same industry consist of intra-industry linkages.

When linkages with suppliers were examined using 1993 input-output data, 99 out of 167 industries are found to have a total of 114 links exceeding 20%. (See Table 2 and Appendix A.) Only one industry has as many as three links greater than 20%, while 13 industries have two links of more than 20% (of these, 2 were intra-industry links), and the remaining 85 industries have only one link greater than 20% (of these, 17 were intra-industry). Some 118 (71%) industries have at least one link between 10% and 20%. The importance of intra-industry backward linkages range from 63.7% to 0% of total shipments, with a mean of 9%. Four industries have intra-industry shares in excess of 50%.

At the 167-industry level, there is considerable variability in the level of industry diversification for backward linkages. For backward linkages, the numbers-equivalent entropy statistic ranges from 44.1 to 2.83, with a mean of 18.6 and a standard deviation of 8.3.

Most industries have one or two links that are very important and most of their other linkages fall in the less important category. Figure 1 plots the average number of links in the different categories. There is, on average, less than one link over 20%, 1.2 between 10% and 20%, 15 between 1% and 10% and 132 between 0% and 1%.

Table 2. Number of Backward Linkages Exceeding 10%

Number of Links	Number of Industries with Links > 20%	Number of Industries with Links Between 10% and 20%
1	85 (17 intra)	64 (10 intra)
2	13 (2 intra)	35 (9 intra)
3	1	15 (5 intra)
4	0	3
5	0	1
Total Links	**114**	**196**

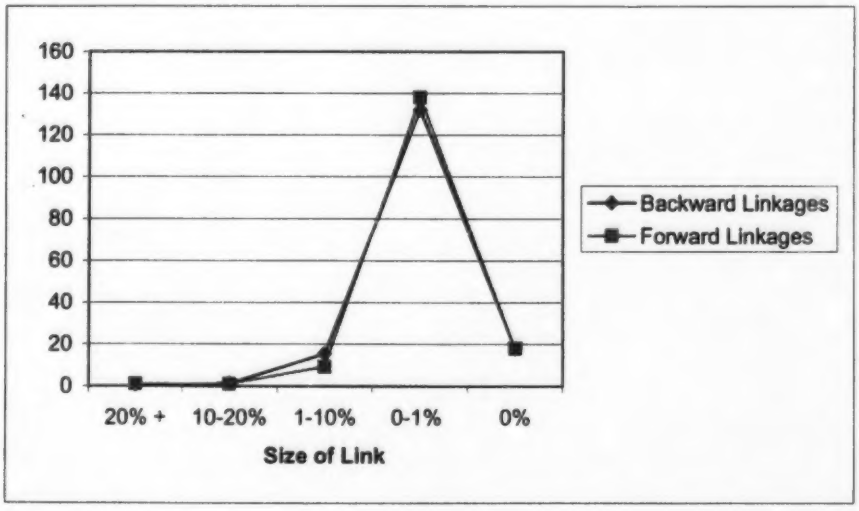
Table 3. Correlation Coefficients for Backward Linkages

	Greater than 20%	Between 10% & 20%	Between 1% & 10%	Between 0 & 1%	Equals Zero	Intra-industry Share
Correlation with Entropy	-0.654	0.217	0.888	-0.066	-0.254	-0.279

Table 4. Number of Forward Linkages Exceeding 10%

Number of Links	Number of Industries with Links > 20%	Number of Industries with Links Between 10% and 20%
1	80 (9 intra links)	64 (8 intra links)
2	35 (15 intra links)	29 (7 intra links)
3	5 (2 intra links)	12 (6 intra links)
4	0	1
Total Links	**165**	**162**

Figure 1. Average Number of Links



Industries with more of the most important links are less diversified using the entropy numbers-equivalent measure. The correlation between the entropy measure (E) and the number of links exceeding 20% is -0.65 (Table 3). But those industries that have more of the most important linkages have fewer linkages in the next most important group—there is a negative correlation (-.57) between the number of links exceeding 20% and those between 10 and 20%. And concomitantly, the entropy measure is positively correlated with the number of links between 10 and 20% (.22). Industries that have less of the most important links tend to have more of the next more important links and this leads to greater diversity overall, at least as measured by the entropy measure. There is also a strong negative correlation (-.61) between the number of the strongest links (over 20%) and the number of links between 1% and 10%. And industries with a large number of these links are much more diversified. A large positive correlation (0.89) exists between the entropy measure (E) and the number of links between 1% and 10% (Table 3).

Finally, there is a weak negative relationship between E and the number of links between 0% and 1% (-0.25). Industries with more of the zero links are negatively correlated (-.94) with the number of links between 0% and 1%. If an industry has relatively few situations where it has no links with other industries, it is more likely to have more of the smallest links. And this tends to increase the diversification index that is being used here.

All of this suggests that our categorical measures are related to but not perfectly congruent with our single summary statistic—the entropy measure. Therefore, the separate measures that have been developed will be kept for our investigation of the relationship between inter-industry links and the importance of innovation networks.

3.2 Number and Magnitude of Forward Linkages with Customers

Industries that have linkages with customers in other industries are characterized as having inter-industry linkages; industries that have linkages with customers in the same industry are characterized as possessing intra-industry links.

The distribution of the number of forward linkages is much the same as for backward linkages (Figure 1). When linkages with customers are examined using 1993 input-output data, 120 industries are found to have a total of 165 links exceeding 20% (Table 4). Five industries have as many as three links greater than 20% (of these, 2 were intra-industry links), while 35 industries have two links of more than 20% (of these, 15 were intra-industry links), and the remaining 80 industries have only one link greater than 20% (of these, 9 were intra-industry). Table 4 contains comparable information on the number of industries with forward linkages between 10% and 20%. Intra-industry forward linkages range from 91.6% to 0% of total shipments, with a mean value of 10%. Four industries have intra-industry shares in excess of 50%.

For forward linkages, the numbers-equivalent entropy measure ranged from 65.6 to 1, with a mean value of 14.5 and a standard deviation of 13.7.

Table 5. Correlation Coefficients for Forward Linkages

	Greater than 20%	Between 10% & 20%	Between 1% & 10%	Between 0 & 1%	Equals Zero	Intra-industry Share
Correlation with Entropy	-0.516	0.243	0.904	0.172	-0.291	-0.165

Table 6. Comparison of Input-Output and Survey Data for Links with Suppliers

Industry	Number of Inter-industry Backward Linkages								
	SIC	% of Firms Relying on Suppliers for Innovation	Greater than 20%	Between 10% & 20%	Between 1% & 10%	Between 0 & 1%	Equals Zero	Intra-industry Share	Entropy
Food, Beverage, Tobacco	10,11,12	30	0.813	1.25	12.81	137.00	15.13	0.1028	14.12
Plastics and Rubber	15,16	35	0.500	0.50	14.50	136.00	15.50	0.0900	18.84
Leather and Clothing	17,24	46	0.906	0.63	12.41	138.00	15.06	0.1001	13.65
Textiles	18,19	40	1.000	0.80	12.00	137.40	15.80	0.1140	11.76
Wood and Furniture	25,26	34	0.625	1.00	15.25	134.75	15.38	0.0559	21.71
Pulp and Paper	27	58	0.750	1.25	12.50	137.00	15.50	0.0659	14.82
Printing and Publishing	28	35	0.500	1.00	17.50	133.00	15.00	0.0576	19.62
Primary Metals	29	23	1.000	0.86	11.57	137.86	15.71	0.1269	13.37
Fabricated Metal Products	30	19	0.875	0.63	17.50	132.88	15.13	0.0793	21.64
Machinery	31	10	0.333	2.00	18.67	131.00	15.00	0.1481	26.91
Transportation Equipment	32	21	0.857	0.57	16.00	134.29	15.29	0.2098	17.18
Electrical Equipment	33	34	0.625	0.63	15.63	134.25	15.88	0.2243	18.97
Non-metallic Minerals	35	30	0.500	0.667	17.17	133.50	15.17	0.0545	24.24
Refined Petroleum	36	45	1.000	0.000	7.00	144.00	15.00	0.0712	3.53
Chemicals and Pharmaceutical	37	25	0.857	1.286	14.29	135.14	15.43	0.1426	17.10
Other Manufacturing	39	23	0.400	1.600	17.80	131.00	16.20	0.0926	27.04
Correlation with Percent Using Supplier Links (prob value for r=0 in brackets)			0.305 (0.25)	-0.399 (0.12)	-0.618 (0.01)	0.628 (0.01)	0.002 (0.99)	-0.380 (0.15)	-0.593 (0.02)
Mean		31.75	0.72	0.92	14.54	135.44	15.39	0.11	17.78
SD		11.90	0.22	0.48	3.05	3.20	0.36	0.05	6.03
CV		0.38	0.31	0.53	0.21	0.02	0.02	0.48	0.34

The correlation between the entropy measure and the categorical measures for forward customer linkages are much the same as they were for backward supplier linkages. At the 167-industry level, a large positive correlation (0.90) was observed between the entropy measure (E) and the number of links between 1% and 10% (Table 5). Weaker correlations were observed between E and the number of links greater than 20% (-0.52), the number of links between 10% and 20% (0.24), and between E and the number of links between 0% and 1% (0.17). Appendix B contains a detailed description of the forward linkages and entropy values for all 167 industries.

4. Comparison of Innovation Networks to Inter-Industry Links

In order to determine whether there is a relationship between the importance of innovation support that comes from customers and suppliers and the size of economic exchanges that take place between industries, the importance of the different types of linkages were correlated with the intensity of the supplier/customer innovation networks.

Several measures of the importance of inter-industry goods and service flows are used—the number of linkages that fall into five categories—above 20%, 10-20%, 1-10%, 0-1%, 0%—, the average share of sales or purchases that consist of intra-industry transactions and finally, the entropy measure. The percentage of firms that reported that their ideas for innovation came from customers and the percentage that came from suppliers is used as a measure of the intensity of the customer/supplier innovation relationship. The innovation survey's coverage provided accurate data only at essentially the 2-digit SIC level. Therefore, the characteristics describing the inter-industry linkages reported in Appendices A and B were averaged for each of the 2-digit industries for which data existed on the use that was made of customer and supplier networks.

The importance of supplier networks varies considerably across industries (Table 6). Only 10% of firms in the machinery sector use suppliers for their innovation ideas; but about 60% of pulp and paper firms do so. The former supplies innovations in the form of machinery to other industries; the latter incorporates new process innovations into its production process by purchasing new machinery and equipment from others.

A significant relationship is observed between the concentration of goods and service flows as provided by the diversity of industry links and the importance of supplier innovation networks (Table 6). There is a statistically significant negative correlation between the numbers-equivalent entropy measure, E, and the percentage use of suppliers as sources of innovation ideas (Table 6). Where there is less cross-industry diversification (as measured by the numbers-equivalent entropy measure), there are more supplier innovation networks.

As previously noted, the entropy numbers-equivalent measure of diversity is larger when there are fewer linkages above 20% and more between 10% and 20% and between 1% and 10%. Therefore, it is not surprising to find that the importance of suppliers as a source of innovation ideas is positively correlated with the first and significantly negatively correlated with the second two categories.

Finally, a negative correlation was found between the size of the intra-industry share and the percentage use of suppliers as sources of ideas. If intra-industry sales are higher, there are fewer supplier innovation networks. This implies that supplier innovation support essentially originates outside the industry of concern.

The results for customer innovation networks contain both similarities and differences to those for supplier networks. As was the case for supplier networks, there is a negative correlation between the importance of consumer innovation networks and the size of the intra-industry share that is weakly significant (Table 7). Consumer networks matter when trade is with firms outside the industry. But contrary to the results for supply networks, customer networks are more likely when the forward linkages are more diverse, though the correlations have a weaker statistical significance than was the case for supplier networks. There is a positive, though not significant, correlation between the entropy measure and the importance of customer networks. This occurs because there is a negative correlation between the importance of customer networks and the number of forward linkages greater than 20%, in contrast to the positive correlation for supplier networks. Customer linkages are positively correlated with the percentage of industries that have linkages between 1 and 20%.

Table 7. Comparison of Input-Output and Survey Data for Links with Customers

Industry	Number of Forward Linkages								
	SIC	% of Firms Relying on Customers for Innovation	Greater than 20%	Between 10% & 20%	Between 1% & 10%	Between 0 & 1%	Equals Zero	Intra-industry Share	Entropy
Food, Beverage, Tobacco	10,11,12	45	1.750	0.69	4.44	158.44	1.69	0.2071	6.60
Plastics and Rubber	15,16	58	1.000	1.00	14.50	148.50	2.00	0.0450	24.47
Leather and Clothing	17,24	18	1.625	0.75	5.19	157.38	2.06	0.1708	8.21
Textiles	18,19	54	1.563	0.69	5.38	157.31	2.06	0.1527	8.02
Wood and Furniture	25,26	28	1.500	0.75	5.75	156.88	2.13	0.1374	8.45
Pulp and Paper	27	61	1.438	0.88	5.50	157.00	2.19	0.1311	8.14
Printing and Publishing	28	54	1.500	0.81	6.06	156.44	2.19	0.1231	8.55
Primary Metals	29	59	1.375	0.81	5.81	156.81	2.19	0.1231	8.28
Fabricated Metal Products	30	50	1.375	0.75	6.69	156.06	2.13	0.1267	9.28
Machinery	31	42	1.375	0.81	6.69	156.00	2.13	0.1315	9.14
Transportation Equipment	32	46	1.375	0.75	6.69	156.13	2.06	0.1512	9.24
Electrical Equipment	33	51	1.313	0.75	7.56	155.31	2.06	0.1165	10.69
Non-metallic Minerals	35	37	1.375	0.813	7.56	155.25	2.00	0.1192	10.78
Refined Petroleum	36	22	1.313	1.000	7.81	154.81	2.06	0.1286	11.02
Chemicals and Pharmaceutical	37	39	1.250	0.938	8.00	154.75	2.06	0.1242	11.03
Other Manufacturing	39	64	1.250	1.000	9.00	153.63	2.13	0.0673	12.30
Correlation with Percent Using Customer Links (prob value for r=0 in brackets)			-0.300 (0.26)	0.124 (0.65)	0.238 (0.37)	-0.239 (0.37)	0.201 (0.45)	-0.444 (0.08)	0.221 (0.41)
Mean		45.50	1.40	0.82	7.04	155.67	2.07	0.13	10.26
SD		13.80	0.17	0.11	2.33	2.26	0.12	0.04	4.07
CV		0.30	0.12	0.13	0.33	0.01	0.06	0.29	0.40

5. *Conclusion*

This paper has investigated how industry linkages with suppliers and customers are connected to innovation strategy. In particular, it has asked whether the extent to which customers and suppliers are involved in innovation networks, through which ideas for innovation are exchanged, is related to the size and pattern of inter-industry goods flows.

In order to answer this question, the nature of inter-industry links and the tendency of one firm to rely upon another as part of an innovation network was examined. There is considerable variability in the extent to which one industry is linked to another. Self-sufficiency is high in some industries. In other cases, there are a small number of important links to other industries. In still other cases, there are links to many other industries.

When linkages with suppliers were examined using 1993 input-output data, industries that have a diverse set of inter-industry links tended to make less use of supplier networks. The same pattern held for the relationship between the size of the intra-industry share and the percentage of innovators who use suppliers as sources of ideas. As the intra-industry share rose, the use of suppliers for ideas fell. In contrast, customer networks are used more intensely when customer networks were more diverse, which suggests that customer networks rely more on a diverse set of information that is being collected, while supplier networks are more likely to be used when the trade link is large enough to make the benefits of co-operation greater than the costs of setting up the co-operative venture.

These findings suggest that innovation networks are related to the types of clustering that takes place within an economy—that the type of industry trade flows influences the creation of innovation networks. But the findings also indicate that clustering has a greater effect on supplier than customer networks. Highly concentrated external flows to suppliers are positively associated with the creation of supplier innovation networks. A larger amount of internal intra-industry flows leads to less networking. This may indicate that advantages of outside networks are greater or that the internal networks are accomplished by other means. The study also found a different relationship between customer networks and downstream inter-industry flows. This suggests that the benefits of customer networks are more diffuse, since they do not tend to follow concentrated trade flows to the same extent.

These findings emphasize that the innovation regime of any economy is inextricably bound up with the industrial structure of that economy. Inter-firm innovation networks are important. But they take on different dimensions. Some involve market transactions with outsiders like consultants. These are relatively unimportant compared to innovation networks that are created between firms that are related either through ownership or through market transactions. The innovation network that operates through related firms will depend upon the extent of inter-firm diversification that occurs through mergers. The links to suppliers and customers, as was shown here, depend on the underlying structure of the production system.

This implies that differences in innovation systems are partially explained by differences in fundamental economic structures. While innovation influences the way in which the economy grows, innovation in turn is related to the structure of that economy at any point in time. In particular, the pattern of goods and services flows conditions the extent to which supplier and customer innovation networks develop.

Appendix A: Backward Linkages by Industry, 1993 Input-Output Data

Number of Backward (Supplier) Links by Industry

	Industry	Greater than 20%	Between 10% & 20%	Between 1% & 10%	Between 0 & 1%	Equals Zero	Intra-share	Entropy
1	Agricultural and Related Service	1	1	14	134	17	0.32	15.48
2	Fishing and Trapping	0	1	17	131	18	0.06	25.78
3	Logging and Forestry	2	0	11	139	15	0.31	10.28
4	Gold Mines	0	4	16	132	15	0.00	20.38
5	Other Metal Mines	0	2	20	130	15	0.00	26.88
6	Iron Mines	0	1	20	130	16	0.17	23.29
7	Asbestos Mines	0	2	18	131	16	0.00	24.33
8	Other Non-metal Mines (except coal)	0	2	20	130	15	0.01	25.16
9	Salt Mines	0	1	21	128	17	0.02	25.60
10	Coal Mines	0	1	19	132	15	0.00	23.94
11	Crude Petroleum and Natural Gas	1	2	14	134	16	0.00	16.63
12	Quarry and Sand Pit	0	3	13	135	16	0.05	23.36
13	Serv. Ind. Incidental to Mineral Extraction	1	0	19	132	15	0.00	19.93
14	Meat and Meat Products (except poultry)	2	0	8	142	15	0.25	4.79
15	Poultry Products	1	1	8	142	15	0.14	4.72
16	Fish Products	1	1	8	142	15	0.11	6.30
17	Fruit and Vegetable	0	3	14	135	15	0.14	20.40
18	Dairy Products	1	1	9	141	15	0.11	6.68
19	Miscellaneous Food Product	0	2	16	134	15	0.15	22.64
20	Feed	1	2	14	135	15	0.13	16.66
21	Vegetable Oil Mills (except corn oil)	1	0	6	145	15	0.00	2.83
22	Biscuit	1	1	15	134	16	0.00	18.45
23	Bread and Other Bakery Products	1	0	16	134	16	0.00	16.14
24	Cane and Beet Sugar	0	1	21	129	16	0.01	22.50
25	Soft Drink	1	1	13	137	15	0.27	14.06
26	Distillery Products	0	2	16	135	14	0.03	21.70
27	Brewery Products	1	2	13	136	15	0.00	17.35
28	Wine	0	2	16	134	15	0.04	19.02
29	Tobacco Products	2	1	12	137	15	0.26	11.72
30	Rubber Products	0	1	17	133	16	0.08	24.49
31	Plastic Products	1	0	12	139	15	0.10	13.18
32	Leather Tanneries	1	1	9	138	18	0.04	9.87
33	Footwear	1	1	20	130	15	0.01	16.28
34	Misc. Leather and Allied Products	1	0	22	127	17	0.04	26.89
35	Man-made Fibre Yarn and Woven Cloth	1	2	11	137	16	0.34	13.98
36	Wool Yarn and Woven Cloth	1	0	14	135	17	0.01	13.17
37	Broad Knitted Fabric	1	1	9	140	16	0.01	7.30
38	Miscellaneous Textile Products	1	0	15	136	15	0.09	16.33
39	Carpet, Mat and Rug	1	1	11	139	15	0.12	8.01
40	Clothing Industries Excluding Hosiery	1	3	8	140	15	0.11	13.58
41	Hosiery	1	0	13	136	17	0.00	9.17
42	Sawmill, Planing Mill and Shingle Mill Products	1	0	7	144	15	0.06	4.38

43	Veneer and Plywood	1	1	9	141	15	0.18	9.69
44	Sash, Door and Other Millwork	1	1	16	134	15	0.06	22.44
45	Wooden Box and Coffin	2	0	10	138	17	0.01	14.20
46	Other Wood	0	3	10	139	15	0.04	18.10
47	Household Furniture	0	1	21	129	16	0.08	34.09
48	Office Furniture	0	1	26	125	15	0.01	35.89
49	Other Furniture and Fixture	0	1	23	128	15	0.01	34.90
50	Pulp and Paper	0	3	11	138	15	0.09	20.21
51	Asphalt Roofing	1	2	12	135	17	0.11	16.58
52	Paper Box and Bag	1	0	11	140	15	0.04	8.37
53	Other Converted Paper Products	1	0	16	135	15	0.02	14.14
54	Printing and Publishing	1	1	14	136	15	0.06	12.64
55	Platemaking, Typesetting and Bindery	0	1	21	130	15	0.05	26.61
56	Primary Steel	0	2	14	136	15	0.19	20.97
57	Steel Pipe and Tube	1	0	8	142	16	0.01	4.44
58	Iron Foundries	0	4	14	134	15	0.02	23.07
59	Non-ferrous Metal Smelting and Refining	2	0	9	140	16	0.21	10.02
60	Aluminium Rolling, Casting and Extruding	2	0	10	139	16	0.38	8.76
61	Copper and Alloy Roll., Cast. and Extr.	1	0	10	139	17	0.01	6.81
62	Other Roll., Cast and Extr. Non-ferrous Metal Products	1	0	16	135	15	0.07	19.53
63	Power Boiler and Structural Metal	1	1	16	134	15	0.15	19.60
64	Ornamental and Architectural Metal Products	1	1	21	129	15	0.06	24.57
65	Stamped, Pressed and Coated Metal Products	1	0	16	135	15	0.03	17.55
66	Wire and Wire Products	1	1	10	140	15	0.17	13.84
67	Hardware, Tool and Cutlery	1	0	22	129	15	0.03	30.25
68	Heating Equipment	0	1	20	131	15	0.09	26.70
69	Machine Shop	1	1	19	130	16	0.02	23.30
70	Other Metal Fabricating	1	0	16	135	15	0.09	17.31
71	Agricultural Implement	0	3	17	132	15	0.05	25.63
72	Commercial Refrig. and Air Cond. Equip.	0	2	20	130	15	0.14	30.20
73	Other Machinery and Equipment	1	1	19	131	15	0.25	24.91
74	Aircraft and Aircraft Parts	1	0	17	134	15	0.51	10.87
75	Motor Vehicle	1	0	8	143	15	0.01	5.65
76	Truck and Bus Body and Trailer	0	2	20	130	15	0.04	33.68
77	Motor Vehicle Parts and Accessories	1	1	17	133	15	0.27	22.16
78	Railroad Rolling Stock	1	0	14	136	16	0.53	9.86
79	Shipbuilding and Repair	1	0	18	133	15	0.06	17.04
80	Misc. Transportation Equipment	1	1	18	131	16	0.04	21.03
81	Small Electrical Appliance	0	1	21	129	16	0.07	28.88
82	Major Appl. (electric and non-electric)	0	1	23	127	16	0.08	32.36
83	Other Electrical and Electronic Product	1	0	20	131	15	0.22	27.38
84	Record Player, Radio and Television Receiver	1	0	9	141	16	0.09	9.08
85	Communic. & Other Electronic Equipment	1	0	10	141	15	0.64	6.91
86	Office, Store and Business Machine	1	0	8	143	15	0.63	5.70
87	Communic. and Energy Wire and Cable	1	1	15	133	17	0.01	17.75
88	Battery	0	2	19	129	17	0.06	23.72
89	Clay Products	0	0	22	130	15	0.04	31.67
90	Hydraulic Cement	0	2	15	135	15	0.03	23.56

91	Concrete Products	1	1	13	137	15	0.00	19.45
92	Ready-mix Concrete	1	1	13	137	15	0.01	10.29
93	Glass and Glass Products	1	0	16	134	16	0.20	23.80
94	Misc. Non-metallic Mineral Products	0	0	24	128	15	0.05	36.66
95	Refined Petroleum and Coal Products	1	0	7	144	15	0.07	3.53
96	Industrial Chemicals n.e.c.	1	2	14	135	15	0.27	16.65
97	Chemical Products n.e.c.	0	2	19	131	15	0.19	22.73
98	Industrial Chemicals n.e.c.	1	1	8	141	16	0.11	9.03
99	Pharmaceutical and Medicine	1	1	14	135	16	0.35	14.84
100	Paint and Varnish	2	0	14	135	16	0.01	17.44
101	Soap and Cleaning Compounds	1	1	13	138	14	0.05	18.74
102	Toilet Preparations	0	2	18	131	16	0.02	20.26
103	Other Manufacturing	0	2	22	128	15	0.16	33.19
104	Jewellery and Precious Metal	1	3	8	138	17	0.17	10.31
105	Sporting Goods and Toy	0	1	25	126	15	0.12	36.92
106	Sign and Display	0	1	19	130	17	0.00	33.26
107	Floor Tile, Linoleum and Coated Fabric	1	1	15	133	17	0.01	21.53
108	Repair Construction	0	0	28	121	18	0.00	44.07
109	Residential Construction	0	2	21	127	17	0.00	36.04
110	Non-residential Building Construction	1	0	23	126	17	0.00	33.98
111	Road, Highway and Airport Runway Constr.	0	2	17	131	17	0.00	24.25
112	Gas and Oil Facility Construction	2	1	8	140	16	0.00	10.47
113	Electric Power, Dams and Irrigation Constr.	0	2	16	131	18	0.00	22.41
114	Railway, and Telecommunication Constr.	1	1	17	130	18	0.00	22.77
115	Other Engineering Construction	1	1	18	132	15	0.00	25.40
116	Construction, Other Activities	1	2	11	135	18	0.00	15.75
117	Air Transport and Related Service	0	3	15	133	16	0.08	18.13
118	Railway Transport and Related Service	1	1	14	133	18	0.09	15.69
119	Water Transport and Related Services	1	0	16	134	16	0.38	14.00
120	Truck Transport	1	1	12	136	17	0.35	12.95
121	Urban Transit Systems	1	1	19	129	17	0.06	20.32
122	Interurban and Rural Transit Systems	0	2	18	130	17	0.02	21.84
123	Miscellaneous Transport Services	0	2	18	131	16	0.06	22.52
124	Pipeline Transport	0	3	14	129	21	0.01	13.79
125	Storage and Warehousing	0	1	24	125	17	0.07	25.46
126	Telecommunication Broadcasting	1	2	15	132	17	0.11	16.83
127	Telecommunication Carriers	0	5	14	130	18	0.06	16.85
128	Postal and Courier Service	0	2	14	135	16	0.15	17.75
129	Electric Power Systems	1	1	16	132	17	0.00	15.25
130	Gas Distribution Systems	0	4	10	135	18	0.00	12.23
131	Water Systems and Other Utility n.e.c.	0	2	17	129	19	0.01	17.28
132	Wholesale Trade	1	1	18	131	16	0.05	22.16
133	Retail Trade	1	0	17	133	16	0.01	18.57
134	Finance and Real Estate	1	0	15	137	14	0.25	15.35
135	Insurance	2	0	7	143	15	0.47	5.82
136	Owner Occupied Dwellings	2	1	2	46	116	0.00	3.03
137	Other Business Services	0	3	10	137	17	0.19	13.57
138	Professional Business Services	0	3	11	137	16	0.19	15.10

139	Advertising Services	0	2	15	132	18	0.00	17.69
140	Educational Service, Private	1	0	17	137	12	0.00	18.99
141	Other Health and Social Service	0	2	19	131	15	0.00	22.91
142	Accommodation and Food Services	0	2	26	123	16	0.04	30.23
143	Motion Picture and Video	1	0	19	132	15	0.46	12.13
144	Other Amusement and Recreational Services	0	1	20	131	15	0.05	21.75
145	Other Personal Service	0	2	20	129	16	0.01	24.61
146	Laundries and Cleaners	0	1	22	127	17	0.01	28.30
147	Membership Org. (excl relig.) and Oth. Services	1	1	13	136	16	0.03	18.91
148	Operating Supplies	0	2	20	110	35	0.00	26.57
149	Office Supplies	1	0	9	113	44	0.00	4.48
150	Cafeteria Supplies	1	1	14	114	37	0.00	14.06
151	Laboratory Supplies	2	1	4	115	45	0.00	5.96
152	Travel and Entertainment	2	1	5	129	30	0.00	6.55
153	Advertising and Promotion	3	0	5	127	32	0.00	5.68
154	Transportation Margins	2	0	4	11	150	0.00	3.74
155	N.B. - P Religious Organizations	0	3	16	130	18	0.00	16.59
156	N.B. - P Welfare Organizations	1	1	19	129	17	0.00	18.09
157	N.B. - P Sports and Recreation Clubs	1	0	19	132	15	0.00	21.71
158	N.B. – P Educational Institutions	0	1	24	130	12	0.00	24.46
159	N.B. – P Other Organizations	1	0	19	132	15	0.00	20.40
160	N.B. – G Hospitals	0	1	20	134	12	0.01	26.90
161	N.B. – G Residential Care Facilities	1	1	16	137	12	0.00	15.39
162	N.B. – G University Education	0	3	18	134	12	0.01	21.54
163	N.B. – G Other Educational Services	0	3	18	134	12	0.02	22.31
164	N.B. – G Defence Services	0	2	22	131	12	0.00	24.68
165	N.B. – G Other Municipal Govt.	0	1	21	133	12	0.08	26.49
166	N.B. – G Other Provincial and Territorial Govt.	1	0	21	134	11	0.01	15.27
167	N.B. – G Other Federal Govt.	0	3	20	133	11	0.02	25.85
Mean		0.68263	1.1737	15.377	131.99	17.77	0.0888	18.603
S.D.		0.64088	1.047	5.0559	12.8305	13.59	0.1259	8.261
C.V.		0.93882	0.892	0.3288	0.0972	0.765	1.418	0.444
Correlation with entropy value		-0.654	0.217	0.888	-0.066	-0.254	-0.279	
Correlation with intra-share		0.23081	-0.18111	-0.21031	0.2132	-0.1199		-0.27864
Correlation with greater than 20%			-0.57276	-0.60797	-0.061	0.28139	0.2308	-0.654
Correlation with 10% to 20%		-0.57276		0.049004	0.0157	-0.083	-0.181	0.21650
Correlation with 1% and 10%		-0.60797	0.049004		-0.0163	-0.3316	-0.2103	0.88845
Correlation with 0% and 1%		-0.06177	0.015774	-0.01631		-0.936	0.21320	-0.06591
Correlation with 0%		0.28139	-0.08313	-0.33164	-0.9360		-0.1199	-0.25406

Appendix B: Forward Linkages by Industry, 1993 Input-Output Data

Number of Forward (Customer) Links by Industry

	Industry	Greater than 20%	Between 10% & 20%	Between 1% & 10%	Between 0 & 1%	Equals Zero	Intra-Share	Entropy
1	Agricultural and Related Service	2	1	10	149	5	0.29	8.80
2	Fishing and Trapping	1	0	3	152	11	0.03	1.45
3	Logging and Forestry	1	2	4	158	2	0.16	3.76
4	Gold Mines	3	0	1	160	3	0.00	3.89
5	Other Metal Mines	1	0	1	163	2	0.00	1.56
6	Iron Mines	1	1	0	161	4	0.16	1.69
7	Asbestos Mines	1	0	5	154	7	0.00	3.35
8	Other Non-metal Mines (except coal)	1	1	4	159	2	0.00	5.61
9	Salt Mines	2	1	9	153	2	0.01	8.35
10	Coal Mines	2	0	2	161	2	0.00	2.43
11	Crude Petroleum and Natural Gas	1	0	5	157	4	0.00	3.56
12	Quarry and Sand Pit	0	3	17	145	2	0.02	17.93
13	Serv. Ind. Incidental to Mineral Extraction	2	0	4	156	5	0.00	3.33
14	Meat and Meat Products (except poultry)	2	1	2	160	2	0.41	4.18
15	Poultry Products	2	2	2	159	2	0.27	5.16
16	Fish Products	2	0	7	156	2	0.38	9.33
17	Fruit and Vegetable	2	1	3	160	1	0.31	7.41
18	Dairy Products	2	1	3	160	1	0.27	5.60
19	Miscellaneous Food Product	2	1	11	152	1	0.23	15.51
20	Feed	1	1	1	162	2	0.13	2.33
21	Vegetable Oil Mills (except corn oil)	3	0	5	157	2	0.01	5.79
22	Biscuit	1	1	4	159	2	0.00	7.86
23	Bread and Other Bakery Products	1	1	2	161	2	0.00	6.31
24	Cane and Beet Sugar	2	1	7	155	2	0.00	7.73
25	Soft Drink	2	0	1	162	2	0.56	3.20
26	Distillery Products	1	1	7	156	2	0.07	6.36
27	Brewery Products	2	0	3	161	1	0.00	4.23
28	Wine	2	1	1	161	2	0.12	2.95
29	Tobacco Products	1	0	2	163	1	0.92	1.83
30	Rubber Products	2	0	12	151	2	0.04	13.94
31	Plastic Products	0	2	17	146	2	0.05	35.00
32	Leather Tanneries	2	1	4	152	8	0.01	5.29
33	Footwear	1	0	6	159	1	0.03	4.46
34	Misc. Leather and Allied Products	1	2	9	153	2	0.03	12.42
35	Man-made Fibre Yarn and Woven Cloth	1	3	7	154	2	0.13	10.49
36	Wool Yarn and Woven Cloth	2	0	10	153	2	0.00	8.99
37	Broad Knitted Fabric	1	0	1	163	2	0.00	1.42
38	Miscellaneous Textile Products	1	0	18	147	1	0.06	23.79
39	Carpet, Mat and Rug	1	2	2	160	2	0.08	4.22
40	Clothing Industries Excluding Hosiery	2	0	7	157	1	0.32	9.17
41	Hosiery	1	0	15	149	2	0.01	26.46
42	Sawmill, Planing Mill and Shingle Mill Products	2	2	7	155	1	0.11	7.78

43	Veneer and Plywood	1	3	7	154	2	0.15	8.14
44	Sash, Door and Other Millwork	1	0	4	160	2	0.05	3.02
45	Wooden Box and Coffin	1	1	18	145	2	0.00	22.26
46	Other Wood	1	2	10	152	2	0.05	12.52
47	Household Furniture	2	1	7	155	2	0.28	9.89
48	Office Furniture	0	2	13	150	2	0.19	27.93
49	Other Furniture and Fixture	0	1	20	145	1	0.04	28.15
50	Pulp and Paper	1	3	3	159	1	0.18	8.64
51	Asphalt Roofing	1	1	8	155	2	0.07	6.24
52	Paper Box and Bag	0	1	21	143	2	0.03	38.77
53	Other Converted Paper Products	1	0	21	143	2	0.02	31.35
54	Printing and Publishing	2	0	5	159	1	0.03	5.46
55	Platemaking, Typesetting and Bindery	1	2	3	159	2	0.02	4.56
56	Primary Steel	0	3	15	148	1	0.12	20.15
57	Steel Pipe and Tube	1	0	14	150	2	0.01	9.75
58	Iron Foundries	1	1	15	148	2	0.01	11.26
59	Non-ferrous Metal Smelting and Refining	1	0	11	153	2	0.35	13.80
60	Aluminium Rolling, Casting and Extruding	1	2	15	147	2	0.24	18.66
61	Copper and Alloy Roll., Cast. and Extr.	0	3	12	145	7	0.00	15.87
62	Oth. Roll., Cast & Extr. Non-ferr. Met. Products	0	2	20	143	2	0.05	27.96
63	Power Boiler and Structural Metal	1	2	9	154	1	0.10	18.26
64	Ornamental and Architectural Metal Product	1	1	8	155	2	0.03	8.41
65	Stamped, Pressed and Coated Metal Product	0	1	19	146	1	0.02	33.34
66	Wire and Wire Products	0	1	20	145	1	0.08	27.68
67	Hardware, Tool and Cutlery	1	0	12	152	2	0.02	17.13
68	Heating Equipment	1	2	6	157	1	0.04	5.87
69	Machine Shop	1	1	9	154	2	0.01	17.55
70	Other Metal Fabricating	1	2	9	154	1	0.03	17.98
71	Agricultural Implement	1	2	4	158	2	0.06	6.51
72	Commercial Refrig. and Air Cond. Equipment	2	0	5	158	2	0.04	4.69
73	Other Machinery and Equipment	1	1	11	153	1	0.18	14.20
74	Aircraft and Aircraft Parts	3	0	1	161	2	0.43	5.22
75	Motor Vehicle	1	1	17	147	1	0.21	43.02
76	Truck and Bus Body and Trailer	1	1	8	155	2	0.07	11.53
77	Motor Vehicle Parts and Accessories	1	0	3	161	2	0.10	2.42
78	Railroad Rolling Stock	1	1	2	161	2	0.63	3.95
79	Shipbuilding and Repair	1	1	6	157	2	0.03	4.55
80	Misc. Transportation Equipment	1	1	10	153	2	0.09	22.76
81	Small Electrical Appliance	1	1	8	155	2	0.07	7.49
82	Major Appl. (electric and non-electric)	1	2	8	154	2	0.10	12.68
83	Other Electrical and Electronic Product	1	1	13	150	2	0.13	18.23
84	Record Player, Radio and Television Receiver	1	0	6	158	2	0.05	3.70
85	Communic. & Other Electronic Equipment	1	1	11	153	1	0.49	8.63
86	Office, Store and Business Machine	2	0	6	157	2	0.49	5.47
87	Communication and Energy Wire and Cable	0	4	12	149	2	0.01	17.39
88	Battery	2	0	8	155	2	0.03	6.24
89	Clay Products	1	2	7	155	2	0.01	8.22
90	Hydraulic Cement	1	1	8	155	2	0.02	4.27

91	Concrete Products	3	1	1	160	2	0.00	5.10
92	Ready-mix Concrete	2	3	2	158	2	0.01	6.83
93	Glass and Glass Products	0	1	21	143	2	0.09	25.39
94	Misc. Non-metallic Mineral Prod.	1	2	12	151	1	0.02	21.52
95	Refined Petroleum and Coal Products	0	1	21	144	1	0.09	41.54
96	Industrial Chemicals n.e.c.	0	3	13	149	2	0.17	21.53
97	Chemical Products n.e.c.	1	1	19	145	1	0.10	28.17
98	Industrial Chemicals n.e.c.	1	1	13	150	2	0.07	14.83
99	Pharmaceutical and Medicine	2	1	5	157	2	0.21	6.30
100	Paint and Varnish	1	3	4	158	1	0.01	15.35
101	Soap and Cleaning Compounds	1	0	16	148	2	0.07	18.23
102	Toilet Preparations	1	1	15	148	2	0.03	24.66
103	Other Manufacturing	0	2	15	148	2	0.07	26.67
104	Jewellery and Precious Metal	2	0	3	160	2	0.54	4.66
105	Sporting Goods and Toy	1	3	7	155	1	0.26	15.39
106	Sign and Display	1	1	4	159	2	0.00	5.06
107	Floor Tile, Linoleum and Coated fabric	1	2	11	151	2	0.00	13.31
108	Repair Construction	0	3	15	138	11	0.00	24.93
109	Residential Construction	0	0	0	0	167	0.00	1.00
110	Non-residential Building Construction	0	0	0	0	167	0.00	1.00
111	Road, Highway and Airport Runway Constr.	0	0	0	0	167	0.00	1.00
112	Gas and Oil Facility Construction	0	0	0	0	167	0.00	1.00
113	Electric Power, Dams and Irrigation Constr.	0	0	0	0	167	0.00	1.00
114	Railway, and Telecommunication Constr.	0	0	0	0	167	0.00	1.00
115	Other Engineering Construction	0	0	0	0	167	0.00	1.00
116	Construction, Other Activities	0	0	24	138	5	0.00	45.42
117	Air Transport and Related Service	1	1	5	159	1	0.07	3.54
118	Railway Transport and Related Service	1	0	6	160	0	0.05	2.90
119	Water Transport and Related Services	2	0	3	156	6	0.25	3.86
120	Truck Transport	1	1	3	162	0	0.18	4.22
121	Urban Transit Systems	3	0	3	157	4	0.29	5.46
122	Interurban and Rural Transit Systems	2	1	4	158	2	0.02	6.32
123	Miscellaneous Transport Services	2	1	6	152	6	0.03	6.62
124	Pipeline Transport	1	0	14	146	6	0.00	29.63
125	Storage and Warehousing	2	0	10	154	1	0.03	9.46
126	Telecommunication Broadcasting	1	0	3	162	1	0.08	2.03
127	Telecommunication Carriers	0	2	20	138	7	0.02	32.53
128	Postal and Courier Service	0	2	14	146	5	0.07	29.54
129	Electric Power Systems	0	0	21	145	1	0.00	49.72
130	Gas Distribution Systems	0	1	18	147	1	0.00	36.13
131	Water Systems and Other Utility n.e.c.	1	1	15	142	8	0.01	29.31
132	Wholesale Trade	0	1	21	144	1	0.03	65.56
133	Retail Trade	0	1	25	141	0	0.02	53.59
134	Finance and Real Estate	0	2	16	146	3	0.19	36.48
135	Insurance	1	0	11	148	7	0.42	14.50
136	Owner Occupied Dwellings	0	0	0	0	167	0.00	1.00
137	Other Business Services	0	1	18	147	1	0.06	29.55
138	Professional Business Services	0	2	20	144	1	0.06	31.63

139	Advertising Services	1	0	0	164	2	0.00	1.03
140	Educational Service, Private	2	1	4	2	158	0.00	4.03
141	Other Health and Social Service	1	0	3	11	152	0.00	1.50
142	Accommodation and Food Services	1	0	6	159	1	0.07	4.31
143	Motion Picture and Video	2	0	5	159	1	0.47	6.95
144	Other Amusement and Recreational Services	1	3	8	155	0	0.19	12.58
145	Other Personal Service	1	1	11	152	2	0.44	10.57
146	Laundries and Cleaners	1	1	13	150	2	0.01	20.34
147	Membership Org. (excl relig.) and Other Serv.	0	1	23	143	0	0.02	49.00
148	Operating Supplies	0	1	22	136	8	0.00	54.28
149	Office Supplies	0	1	20	138	8	0.00	32.88
150	Cafeteria Supplies	0	2	13	80	72	0.00	14.62
151	Laboratory Supplies	1	1	16	102	47	0.00	30.21
152	Travel and Entertainment	1	1	14	142	9	0.00	34.69
153	Advertising and Promotion	0	2	16	140	9	0.00	38.70
154	Transportation Margins	0	0	24	141	2	0.00	60.33
155	N.B. - P Religious Organizations	0	0	0	0	167	0.00	1.00
156	N.B. - P Welfare Organizations	0	0	0	0	167	0.00	1.00
157	N.B. - P Sports and Recreation Clubs	2	0	4	9	152	0.01	3.20
158	N.B - P Educational Institutions	0	0	0	0	167	0.00	1.00
159	N.B. - P Other Organizations	1	0	14	120	32	0.00	9.54
160	N.B. - G Hospitals	1	1	11	151	3	0.05	10.14
161	N.B. - G Residential Care Facilities	1	0	2	9	155	0.00	1.41
162	N.B. - G University Education	1	1	18	144	3	0.02	25.18
163	N.B. - G Other Educational Services	2	1	4	152	8	0.11	5.10
164	N.B. - G Defence Services	0	1	19	145	2	0.02	36.99
165	N.B. - G Other Municipal Govt.	0	2	20	144	1	0.15	37.48
166	N.B. - G Other Provincial and Territorial Govt.	0	2	17	148	0	0.19	22.48
167	N.B. - G Other Federal Govt.	0	2	20	145	0	0.08	32.84
Mean		0.9880	0.9701	9.1796	138.0898	17.7725	0.0970	14.5246
S.D.		0.7838	0.9406	6.8074	43.9345	46.5176	0.1468	13.7530
C.V.		0.7933	0.9696	0.7416	0.3182	2.6174	1.5137	0.9469
Correlation with entropy		-0.516	0.243	0.904	0.172	-0.291	-0.165	
Correlation with intra-share		0.294	-0.034	-0.169	0.259	-0.224		-0.165
Correlation with greater than 20%			-0.270	-0.492	0.335	-0.256	0.294	-0.516
Correlation with 10% to 20%		-0.270		0.249	0.259	-0.296	-0.034	0.243
Correlation with 1% and 10%		-0.492	0.249		0.240	-0.370	-0.169	0.904
Correlation with 0% and 1%		0.335	0.259	0.240		-0.991	0.259	0.172
Correlation with 0%		-0.256	-0.296	-0.370	-0.991		-0.224	-0.291

Appendix C

Industry	L	SIC
Agriculture and Related Service	1	011,012-017,021-023
Fishing and Trapping	2	031-033
Logging and Forestry	3	041,051
Gold Mines	4	0611
Other Metal Mines	5	0612-0616,0619
Iron Mines	6	0617
Asbestos Mines	7	0621
Other Non-metal Mines (except coal)	8	0622-0624,0629
Salt Mines	9	0625
Coal Mines	10	063
Crude Petroleum and Natural Gas	11	071
Quarry and Sand Pit	12	081,082
Services Ind. Incidental to Mineral Extraction	13	091,092
Meat and Meat Products (except poultry)	14	1011
Poultry Products	15	1012
Fish Products	16	102
Fruit and Vegetable	17	103
Dairy Products	18	104
Miscellaneous Food Products	19	1051,1052,1082,1083,1091-1099
Feed	20	1053
Vegetable Oil Mills (except corn oil)	21	106
Biscuit	22	1071
Bread and Other Bakery Products	23	1072
Cane and Beet Sugar	24	1081
Soft Drink	25	111
Distillery Products	26	112
Brewery Products	27	113
Wine	28	114
Tobacco Products	29	121,122
Rubber Products	30	151,152,159
Plastic Products	31	161-163,1691,1699
Leather Tanneries	32	1711
Footwear	33	1712
Misc. Leather and Allied Products	34	1713,1719
Man-made Fibre Yarn and Woven Cloth	35	181,1829
Wool Yarn and Woven Cloth	36	1821
Broad Knitted Fabric	37	183
Miscellaneous Textile Products	38	191-193,199
Carpet, Mat and Rug	39	192
Clothing Industries Excluding Hosiery	40	243-245,2491-2493,2495-2499
Hosiery	41	2494
Sawmill, Planing Mill and Shingle Mill Products	42	251
Veneer and Plywood	43	252
Sash, Door and Other Millwork	44	2541,2542,2543,2549
Wooden Box and Coffin	45	256,258
Other Wood	46	2592,2593,2591,2599
Household Furniture	47	261
Office Furniture	48	264
Other Furniture and Fixture	49	269
Pulp and Paper	50	2711-2719

Asphalt Roofing	51	272
Paper Box and Bag	52	273
Other Converted Paper Products	53	279
Printing and Publishing	54	281,283,284
Platemaking, Typesetting and Bindery	55	282
Primary Steel	56	2911,2912,2919
Steel Pipe and Tube	57	292
Iron Foundries	58	294
Non-ferrous Metal Smelting and Refining	59	295
Aluminium Rolling, Casting and Extruding	60	296
Copper and Alloy Roll., Cast. and Extr.	61	297
Oth. Roll., Cast & Extr. Non-ferr. Metal Products	62	299
Power Boiler and Structural Metal	63	301,3021-3023,3029
Ornamental and Architectural Metal Prod.	64	303
Stamped, Pressed and Coated Metal Prod.	65	304
Wire and Wire Products	66	305
Hardware, Tool and Cutlery	67	306
Heating Equipment	68	307
Machine Shop	69	308
Other Metal Fabricating	70	309
Agricultural Implement	71	311
Commercial Refrig. and Air Cond. Equipment	72	312
Other Machinery and Equipment	73	3191-3193,3194,3199
Aircraft and Aircraft Parts	74	321
Motor Vehicle	75	323
Truck and Bus Body and Trailer	76	324
Motor Vehicle Parts and Accessories	77	3251-3257,3259
Railroad Rolling Stock	78	326
Shipbuilding and Repair	79	327
Misc. Transportation Equipment	80	328-329
Small Electrical Appliance	81	331
Major Appl. (electric and non-electric)	82	332
Other Electrical and Electronic Product	83	333,3371,3372,3379,3392,3399
Record Player, Radio and Television Receiver	84	334
Communic. and Other Electronic Equipment	85	3351,3352,3359
Office, Store and Business Machine	86	3361,3362,3369
Communic. and Energy Wire and Cable	87	338
Battery	88	3391
Clay Products	89	351
Hydraulic Cement	90	352
Concrete Products	91	354
Ready-mix Concrete	92	355
Glass and Glass Products	93	356
Misc. Non-metallic Mineral Prod.	94	357,358,359
Refined Petroleum and Coal Products	95	361,369
Industrial Chemicals n.e.c.	96	3711,3712
Chemical Products n.e.c.	97	372,379
Plastic and Synthetic Resin	98	373
Pharmaceutical and Medicine	99	374
Paint and Varnish	100	375
Soap and Cleaning Compounds	101	376
Toilet Preparations	102	377
Other Manufacturing	103	3911,3914,3991,3992,3994,3999
Jewellery and Precious Metal	104	392
Sporting Goods and Toy	105	3931,3932
Sign and Display	106	397

Floor Tile, Linoleum and Coated Fabric	107	3993
Repair Construction	108	401-449
Residential Construction	109	401-449
Non-residential Building Construction	110	401-449
Road, Highway and Airport Runway Constr.	111	401-449
Gas and Oil Facility Construction	112	401-449
Electric Power, Dams and Irrigation Constr.	113	401-449
Railway and Telecommunication Constr.	114	401-449
Other Engineering Construction	115	401-449
Construction, Other Activities	116	401-449
Air Transport and Related Service	117	451,452
Railway Transport and Related Service	118	453
Water Transport and Related Services	119	454,455
Truck Transport	120	456
Urban Transit Systems	121	4571
Interurban and Rural Transit Systems	122	4572
Miscellaneous Transport Services	123	4573-4575,458,459
Pipeline Transport	124	4611,4612,4619
Storage and Warehousing	125	471,479
Telecommunication Broadcasting	126	4811-4814
Telecommunication Carriers	127	482,483
Postal and Courier Service	128	484
Electric Power Systems	129	491
Gas Distribution Systems	130	492
Water Systems and Other Utility n.e.c.	131	493, 499
Wholesale Trade	132	501-599
Retail Trade	133	601-692
Finance and Real Estate	134	701-705,709,711-729, 741-749,7511,7512,759,761
Insurance	135	731,732,733
Owner Occupied Dwellings	136	7513
Other Business Services	137	771,772,777,779
Professional Business Services	138	773,775,776
Advertising Services	139	774
Educational Service, Private	140	851,852,854-859
Other Health and Social Service	141	862-869
Accommodation and Food Services	142	911-914,921,922
Motion Picture and Video	143	961,962
Other Amusement and Recreational Services	144	963-966,969
Other Personal Service	145	971,973,974,979
Laundries and Cleaners	146	972
Membership Org. (excl relig.) and Other Services	147	982-986,991-996,999
Operating Supplies	148	
Office Supplies	149	
Cafeteria Supplies	150	
Laboratory Supplies	151	
Travel and Entertainment	152	
Advertising and Promotion	153	
Transportation Margins	154	
N.B. - P Religious Organizations	155	981
N.B. - P Welfare Organizations	156	864
N.B. - P Sports and Recreation Clubs	157	961-969
N.B. - P Educational Institutions	158	851,852,854-859

N.B. - P Other Organizations	159	3999,4571,4811-4813,601-692, 711-729,741-749,751,759,761, 771,773,775-777, 779,862-869, 911-914,921,922,971,973, 974,979,982-986,991-999
N.B. - G Hospitals	160	861
N.B. - G Residential Care Facilities	161	862
N.B. - G University Education	162	853
N.B. - G Other Educational Serv.	163	851,852,854-859
N.B. - G Defence Services	164	811
N.B. - G Other Municipal Govt.	165	451,452,459,493,499,751,759, 832-837,862-864,867,869,963-965,969,971,973,974,979,982-986,999
N.B. - G Other Provincial and Territorial Govt.	166	021-023,031-033,051,3999,451, 452,454,455,459,4811-4813, 493,499,711-729,731-733,741-749,751,759,822-827,862-969, 911-914,921,922,961,963-966, 969,982-986,996
N.B. - G Other Federal Govt.	167	051,451,452,454,455,459, 4811-4813,711,729,731-733, 741-749,751-759,812-817,911-914,921,922,961,963-965,969

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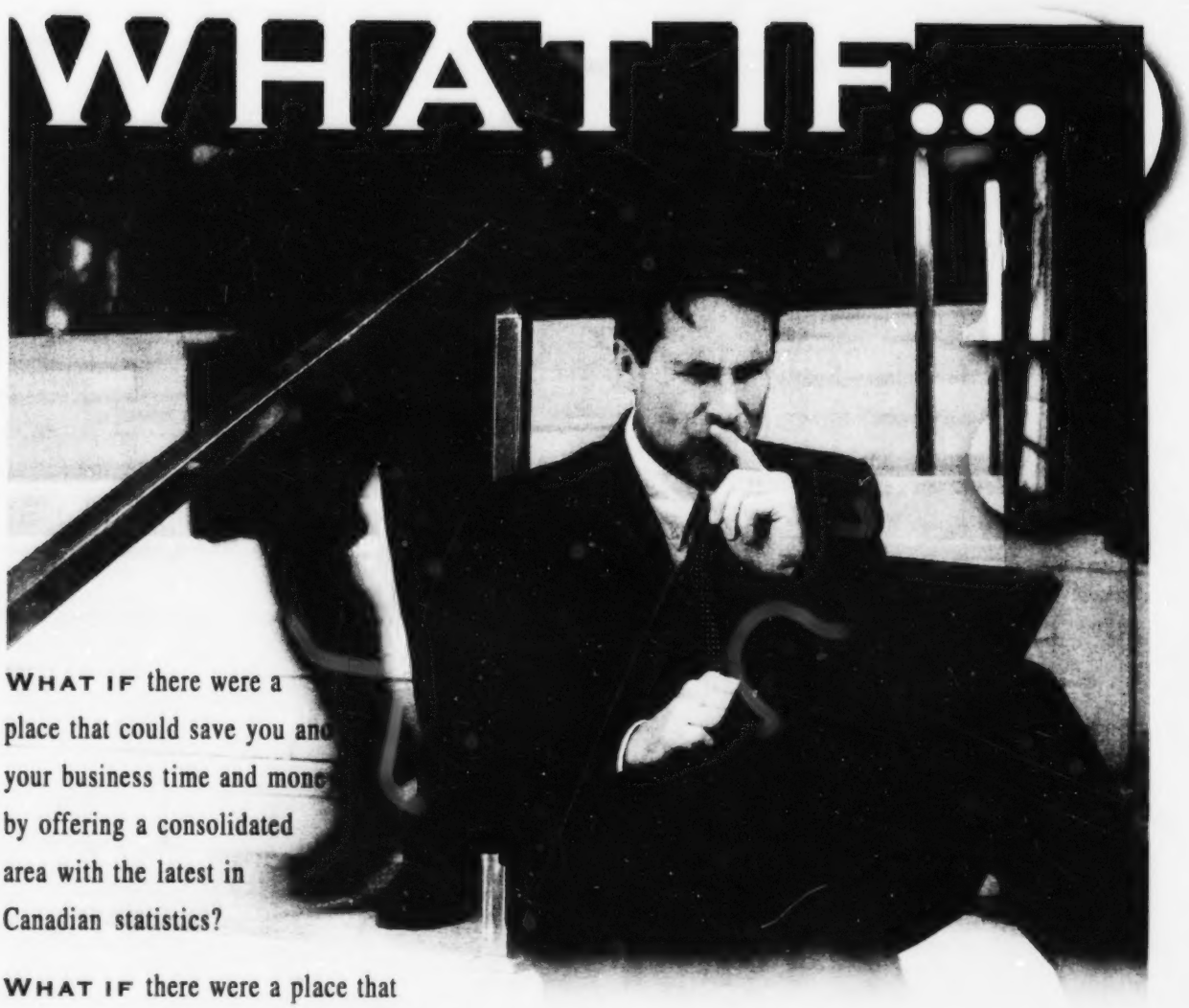

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